Notice No.8

Rules and Regulations for the Classification of Ships, July 2018

The status of this Rule set is amended as shown and is now to be read in conjunction with this and prior Notices. Any corrigenda included in the Notice are effective immediately.

Please note that corrigenda amends to paragraphs, Tables and Figures are not shown in their entirety.

Issue date: June 2019

Amendments to	Effective date	IACS/IMO implementation (if applicable)
Part 5, Chapter 2, Sections 2, 7, 11 & 15	1 July 2019	N/A
Part 5, Chapter 2, Section 15	1 July 2019	1 July 2019
Part 5, Chapter 14, Section 4	1 July 2019	1 July 2019
Part 5, Chapter 21, Section 1	1 July 2019	1 July 2019
Part 6, Chapter 2, Sections 9 & 21	1 July 2019	N/A
Part 7, Chapter 12, Sections 1, 2, 3, 4, 5 & 7	1 July 2019	N/A
Part 8, Chapter 1, Sections 1, 2, 3 & 4	1 July 2019	N/A
Part 8, Chapter 2, Sections 2, 10, 11 & 12	1 July 2019	N/A

Lloyd's Register

Part 5, Chapter 2
Reciprocating Internal Combustion Engines

■ *Section 2*
Materials and Components

2.2 Testing and inspection

2.2.1 Materials and components for engines are to be manufactured, tested and documented in accordance with ~~the relevant requirements of the *Rules for the Manufacture, Testing and Certification of Materials, July 2018, incorporating Notice No. 1*~~ and *Table 2.2.1 Summary of testing and associated documentation for engine components* under a quality control system that is suitable for the actual engine types to be certified by LR. *See also* the applicable requirements specified in the *Rules for the Manufacture, Testing and Certification of Materials, July 2018, incorporating Notice No. 1*.

2.2.5 The manufacturer is not exempted from responsibility for any relevant tests and inspections of those parts for which documentation is not explicitly requested by LR. Manufacturers are to be equipped in such a way that all materials and components can be consistently produced to the required standard. This includes production and assembly lines, machining units, special tools and devices, assembly and testing rigs as well as all lifting and transportation devices.

(Part only shown)

Table 2.2.1 Summary of testing and associated documentation for engine components

Part	Material properties *see* Note 2	Non-destructive examination	Hydraulic testing *see* Note 4	Dimensional inspection *see* Note 3	Visual inspection	Applicable to engines	Final document to be issued
Bolts and studs for cylinder heads, crossheads, main bearings and connecting rods *see* Note ~~9~~8	W (C + M)	W (UT + CD)	-	TR [thread making for connecting rods]	-	B>300mm	W Material Properties Certificate W Non-Destructive Examination Report W Test Report
Tie rod *see* Note ~~10~~9	W (C + M)	W (UT + CD)	-	TR [thread making]	LR(V) (Random)	Crosshead	LR Component Certificate
High pressure fuel injection system – valve and pump body (pressure side) *see* Notes ~~11~~10 and ~~12~~11	~~LR(C + M)~~ ~~*see* Note 8~~ -	-	W (Lesser of *P* or *p*+30 MPa) TR (Lesser of P or *p*+30 MPa)	-	-	B>300mm B≤300mm	~~LR Component Certificate~~ ~~*see* Note 8~~ W Hydraulic Test Certificate or Test Report
High pressure fuel injection pipes including common rail *see* Note ~~11~~10	~~LR(C + M)~~ ~~*see* Note 8~~ W (C + M)	-	W (Lesser of *P* or *p*+30 MPa) TR (Lesser of P or *p*+30 MPa)	-	-	B>300mm B≤300mm	~~LR Component Certificate~~ ~~*see* Note 8~~ W Material Properties Certificate W Hydraulic Test Certificate or Test Report
High pressure common servo oil system	~~LR(C + M)~~ ~~*see* Note 8~~ W (C + M)	-	W (Lesser of *P* or *p*+30 MPa) TR (Lesser of P or *p*+30 MPa)	-	-	B>300mm B≤300mm	~~LR Component Certificate~~ ~~*see* Note 8~~ W Material Properties Certificate

							W Hydraulic Test Certificate or Test Report
Coolers, both sides *see* Note ~~13~~ 12	~~LR(C + M)~~ ~~*see* Note 8~~ W (C + M)	-	W (P)	-	-	B>300mm	~~LR Component Certificate~~ ~~*see* Note 8~~ W Material Properties Certificate W Hydraulic Test Certificate
Accumulator of common rail fuel or servo oil system	~~LR(C + M)~~ ~~*see* Note 8~~ W (C + M)	-	W (Lesser of P or *p*+30 MPa)	-	-	Accumulators with a capacity >0,5l	~~LR Component Certificate~~ ~~*see* Note 8~~ W Material Properties Certificate W Hydraulic Test Certificate
Piping, pumps, actuators, etc., for hydraulic drive of valves, if applicable	~~LR(C + M)~~ ~~*see* Note 8~~ W (C + M)	-	W (P)	-	-	>800kW/cylinder	~~LR Component Certificate~~ ~~*see* Note 8~~ W Material Properties Certificate W Hydraulic Test Certificate
Engine-driven pumps (oil, water, fuel, bilge)	~~LR(C + M)~~ ~~*see* Note 8~~ -	-	W (P)	-	-	>800kW/cylinder	~~*see* Note 8~~ W Hydraulic Test Certificate
Bearings (main, crosshead, and crankpin) *see* Note ~~14~~13	TR [C]	TR [UT]	-	W	-	>800kW/cylinder	TR Material Properties TR Non-Destructive Examination Report W Inspection Certificate

~~Note 8. Where piping systems and components are categorised as Class III, the testing for material properties shall be W(C + M) as a minimum. For materials documentation requirements, *see Pt 5, Ch 12, 1.7 Materials.* W Hydraulic Test Certificate or Test Report will also form as part of Final Document to be Issued.~~

Existing Notes 9 to 14 have been renumbered 8 to 13.

■ *Section 7*
Control and monitoring of main, auxiliary and emergency engines

7.3 Auxiliary engine governors

7.3.5 For alternating current installations, the permanent speed variation of the machines intended for parallel operation are to be equal within a tolerance of ± 0,5 per cent. Momentary speed variations with load changes in accordance with *Pt 5, Ch 2, 7.3 Auxiliary engine governors 7.3.1* are to return to and remain within one per cent of the final steady state speed. ~~This should normally be accomplished within five but in no case more than eight seconds.~~ This is to be accomplished within a maximum of 5 seconds; longer durations are subject to consideration by LR and are to be supported by an engineering and safety justification. For quality of power supplies, *see Pt 6, Ch 2, 1.8 Quality of power supplies.*

■ *Section 11*
Factory Acceptance Test and Shipboard Trials of Engines

11.1 Safety

11.1.3 The low-pressure gas fuel piping on the engine is to be verified as gastight prior to the engine being started.

11.3 Works trials (factory acceptance test)

11.3.3 For each trial condition the parameters to be recorded include: Power and speed; Fuel index, both gas and fuel oil as applicable (or equivalent reading); Gas pressure and temperature; Maximum combustion pressures; Exhaust gas temperature before turbine and from each cylinder (or from manifold, *see* Note 5 in *Table 2.7.1 Engines for propulsion purposes: Alarms and slow-downs*); Charge air temperature and pressure, and turbocharger speed (only for category B and C turbochargers).

11.3.7 Alternatives to the detailed tests may be agreed between the manufacturer and LR when the overall scope of tests is found to be equivalent. The scope of the trials may be expanded depending on the engine application, service experience, or other relevant reasons. Dual fuel (DF) engines using low pressure methane shall be tested in both fuel oil and gas mode as applicable.

11.3.10 Gas fuel (GF) only and DF engines using low pressure methane are to undergo integration tests to verify correct operation of the complete mechanical, hydraulic and electronic system for all intended operational modes. The scope of these tests is to be agreed with LR and is to be based on the results of the risk analysis required in *Pt 5, Ch 2, 15.3 Risk analysis*. Tests are to include, but not be limited to:

- failure of ignition (spark ignition or pilot injection systems), for one-cylinder unit;
- failure of a cylinder gas supply valve;
- failure of the combustion (to be detected by e.g. misfiring, knocking, exhaust temperature deviation, etc.);
- abnormal gas pressure;
- abnormal gas temperature.

The above tests may be carried out by simulation or other alternative methods subject to special consideration and agreement by LR.

Existing paragraphs 11.3.10 to 11.3.11 have been renumbered 11.3.11 to 11.3.12.

11.4 Shipboard trials

11.4.6 The suitability of an engine to burn residual or other special fuels is to be demonstrated~~,~~ where the machinery installation is arranged to burn such fuels in service. ~~Dual~~ DF or multi-fuel engines are to be tested on all fuels that the engine is specified to use. Where engines operate on a mix of different fuels then this is to be demonstrated. *See also Pt 6, Ch 1, 7.2 Unattended machinery space operation - UMS notation 7.2.1*.

■ *Section 15*
Engines supplied with low pressure gas

15.1 General

15.1.1 Sections *Pt 5, Ch 2, 15.1 General* to *Pt 5, Ch 2, 15.14 Control, monitoring, alarm and safety systems* detail the requirements for trunk piston internal combustion engines supplied with low pressure (less than 1 MPa) natural gas (methane) as fuel. Engines may be either dual fuel engines (hereinafter referred to as DF engines) or gas fuel only engines (hereinafter referred to as GF engines).

15.1.2 The requirements apply to engine in which gas is introduced either into the air inlet manifold, scavenge space or cylinder air inlet channel port or mixed with air before the turbocharger ('pre-mixed engines') and the gas/air mixture in the cylinder is ignited by the combustion of a certain amount of fuel (pilot injection) or by extraneous ignition (sparking plug).

15.1.3 The requirements apply to, but are not limited to, engines for mechanical propulsion and generating sets intended for main propulsion and auxiliary applications in single engine or multi-engine installations.

15.1.4 In addition to the requirements described in this Chapter, the requirements relating to engines in the following Rule sets are also to be satisfied:

- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk, July 2018, Incorporating Notice No.1,* and
- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels, July 2018, Incorporating Notice No. 1 & 2.*

15.1.5 Type testing requirements are given in LR's *Type Approval System Test Specification Number 4*.

15.1.6 Factory acceptance test and shipboard trial requirements are given in *Pt 5, Ch 2, 11 Factory Acceptance Test and Shipboard Trials of Engines*.

15.2 Submission requirements

15.2.1 The plans and particulars are to be submitted as required in *Table 2.15.1 Plans and particulars to be submitted* in addition to those required in *Pt 5, Ch 2, 1.4 Submission requirements 1.4.1*.

Table 2.15.1 Plans and particulars to be submitted

Document	For information (X indicates required submission)	For appraisal
For both DF and GF engines:		
• Schematic layout or other equivalent documents of gas system on the engine		X
• Gas piping system (including double-walled arrangement where applicable)		X
• Parts for gas admission system, *see* Note 1		X
• Arrangement of explosion relief valves (crankcase, *see* Note 2), charge air manifold, exhaust gas manifold) as applicable		X
• List of certified safe equipment and evidence of relevant certification		X
• Safety concept, *see* Note 3	X	
• Report of the risk analysis, *see* Note 4	X	
• Gas specification	X	
For DF engine only:		
• Schematic layout or other equivalent documents of fuel oil system (main and pilot fuel systems) on the engine		X
• Shielding of high pressure fuel pipes for pilot fuel system, assembly		X
• High pressure parts for pilot fuel oil injection system, *see* Note 1		X
For GF engine only:		
• Ignition system		X
Note 1. The documentation to contain specification of pressures, pipe dimensions and materials.		
Note 2. If required in *Pt 5, Ch 2, 1.4 Submission requirements 1.4.1.*		
Note 3. *See Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels, July 2018, Incorporating Notice No.1 & 2, Part A-1, Part A-1 5.6 Regulations for ESD-protected machinery spaces LR 5.6-02.*		
Note 4. *See Pt 5, Ch 2, 15.3 Risk analysis.*		

15.2.2 Where considered necessary to verify the requirements of this Chapter have been satisfied, LR may request further documents to be submitted.

15.3 Risk analysis

15.3.1 A risk analysis shall be carried out by the engine manufacturer to:

- identify any reasonably foreseeable normal and abnormal failures which may lead to the presence of gas in components or locations not designed for such purpose;
- evaluate the consequences including rupture, fire or explosion;
- identify the failure detection method where necessary;
- identify the corrective measures where the risk cannot be eliminated:
    - o in the system design, such as redundancies and safety devices, monitoring or alarm provisions which permit restricted operation of the system;
    - o in the system operation, such as, but not limited to, initiation of the redundancy and activation of an alternative mode of operation.

15.3.2 Risk analysis shall be undertaken to a recognised standard, e.g. ISO 31010:2009, and documented in accordance with LR's *ShipRight Procedure for Risk Based Designs (RBD)* and associated annexes.

15.3.3 Only single failures shall be considered at one time. Both detectable and non-detectable failures shall be considered. Failures of any component directly caused by a single failure of another component shall also to be considered (i.e. consequence failures).

15.3.4 The risk analysis for the engine is to include, but not be limited to:

- failure of the gas-related systems or components, in particular, gas piping and its enclosure, where provided, and cylinder gas supply valves. It shall be noted that failures of the gas supply components not located directly on the engine, such as valves and other components of the gas valve unit (GVU), are not to be considered in the analysis.
- failure of the ignition system (fuel oil pilot injection or sparking plugs).
- failure of the air to fuel ratio control system (charge air by-pass, gas pressure control valve, etc.).
- for engines where gas is injected upstream of the turbocharger compressor, failure of a component likely to result in a source of ignition (hot spots).
- failure of the gas combustion or abnormal combustion (misfiring, knocking).
- failure of the engine monitoring, control and safety systems. Where engines incorporate electronic control systems, a Failure Mode and Effects Analysis (F.M.E.A) is to be carried out in accordance with Note 10 in *Table 2.1.1 Plans and particulars to be submitted*.
- abnormal presence of gas in engine components (e.g. air inlet manifold and exhaust manifold of DF or GF engines) and in the external systems connected to the engines (e.g. exhaust duct).
- changes of operating modes for DF engines.
- hazard potential for crankcase fuel gas accumulation, for engines where the underside of the piston is in direct communication with the crankcase, *see Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels, July 2018, Incorporating Notice No.1 & 2, Pt A-1, 10.3 Regulations for internal combustion engines of piston type 10.3.1.2*.

15.3.5 The risk analysis for the engine shall also take into account the impact of the following external events:

- a gas leakage downstream of the GVU. The GVU is a set of manual shut-off valves, actuated shut-off and venting valves, gas pressure sensors and transmitters, gas temperature sensors and transmitters, gas pressure control valve and gas filter used to control the gas supply to each gas consumer. It also includes a connection for inert gas purging.
- the safety of the engine in case of an externally activated emergency shutdown or blackout, when running on gas;
- the interactions between the gas fuel system and the engine;
- failures in systems external to the engine that impact safe engine operation, such as ship fuel storage or fuel gas supply systems. This may require action from the engine control and monitoring system in the event of an alarm or fault condition.

15.4 Design requirements

15.4.1 The allowable gas composition limits for the engine and the minimum and (if applicable) maximum methane number shall be specified by the manufacturer.

15.4.2 Components containing or likely to contain gas shall be designed to:

- minimise the risk of fire and explosion so as to demonstrate an equivalent level of safety to an oil-fuelled engine;
- mitigate the consequences of a possible explosion, through adequate strength of the component(s) or the fitting of suitable pressure relief devices of an approved type.

See:

- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, *July 2019, Incorporating Notice No.1 & 2, Pt A-1 10 Power Generation Including Propulsion and Other Gas Consumers;* or
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk, July 2019, Incorporating Notice No.1, Ch 16, 16.7 Special requirements for gas-fired internal combustion engines*.

15.4.3 Discharge from pressure relief devices shall prevent the passage of flame to the machinery space and be arranged such that the discharge does not endanger personnel or damage other engine components or systems.

15.4.4 Relief devices shall be fitted with a flame arrester,

See:

- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, *July 2019, Incorporating Notice No.1 & 2, Pt A-1 10.3 Regulations for internal combustion engines of piston type*; or
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk, July 2019, Incorporating Notice No.1, Ch 16 Use of Cargo as Fuel*.

15.5 Gas piping

15.5.1 Engine-mounted gas piping shall be designed in accordance with:

- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, *July 2019, Incorporating Notice No.1 & 2, Pt A-1* 7 *Material and General Pipe Design*; or
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk, July 2019, Incorporating Notice No.1, Ch 16 Use of Cargo as Fuel*.

15.5.2 Pipes and equipment on the engine containing fuel gas are to be considered as hazardous area Zone 0, whereas the space between the gas fuel piping and the wall of the outer pipe or duct is defined as hazardous area Zone 1,

See:

- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, *July 2018, Incorporating Notice No.1 & 2, Part A-1, 12.5 Hazardous area zones*

15.5.3 Double wall gas piping systems on the engine are to be arranged in accordance with:

- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, *July 2018, Incorporating Notice No.1 & 2, Part A-1, 9.6 Regulations for fuel supply to consumers in gas-safe machinery spaces*; or
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk*, *July 2018, Incorporating Notice No.1, Ch 16, 16.4 Gas fuel supply, 16.4.3.*

15.5.4 Double wall pipes or ducts are to be designed in accordance with:

- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, *July 2018, Incorporating Notice No.1 & 2, Part A-1, 9.8 Regulations for the design of ventilated duct, outer pipe against inner pipe gas leakage;* and
- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, *July 2018, Incorporating Notice No.1 & 2, Part A-1, 7.4 Regulations for materials 7.4.1.4; or*
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk, July 2018, Incorporating Notice No.1, Ch 16 Use of Cargo as Fuel.*

15.5.5 For a ventilated double wall gas pipes on the engine, the ventilation inlet shall be located in accordance with:

- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, *July 2018, Incorporating Notice No.1 & 2, Part A-1*, *13.8 Regulations for ducts and double pipes 13.8.3*; or
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk, July 2018, Incorporating Notice No.1, Ch 16, 16.4 Gas fuel supply, 16.4.3.2.*

15.5.6 The pipe or duct is to be pressure tested to ensure gastight integrity and to show that it can withstand the expected maximum pressure at gas pipe rupture in accordance with:

- *Pt 5, Ch 12, 8.1 Hydraulic tests before installation on board*

15.5.7 Single wall piping is only acceptable for engines intended to be installed in emergency shutdown (ESD)-protected machinery spaces or an appropriate ducting arrangement provided, in accordance with:

- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels, July 2019, Incorporating Notice No.1 & 2, Part A-1, 5.4 Machinery space concepts 5.4.1.2 and Part A-1 5.6 Regulations for ESD-protected machinery spaces*; and
- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels, July 2019, Incorporating Notice No.1 & 2, Part A-1, 9.6 Regulations for fuel supply to consumers in gas-safe machinery spaces 9.6.2.*

15.6 Charge air system

15.6.1 The charge air system on the engine shall be designed in accordance with:

- *Pt 5, Ch 2, 15.4 Design requirements 15.4.2*.

15.6.2 Engines designed for single engine installations providing power for propulsion or other essential services shall be capable of continued operation after opening of the pressure relief valves. LR is to be advised of any reduction in output power following such an event which is to be stated in the operating manuals.

15.7 Exhaust system

15.7.1 The exhaust gas system on the engine shall be designed in accordance with:

- *Pt 5, Ch 2, 15.4 Design requirements 15.4.2*.

15.7.2 Single engine installations are to comply with:

- *Pt 5, Ch 2, 15.6 Charge air system 15.6.2*.

15.8 Crankcase

15.8.1 Crankcase explosion relief valves shall be installed in accordance with:

- *Pt 5, Ch 2*, *10.1 Relief valves* to *Pt 5, Ch 2, 10.3 Size of relief valves*. *See also Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, *July 2018, Incorporating Notice No.1 & 2, Pt A-1 10.3 Regulations for internal combustion engines of piston type 10.3.1.2*.

15.8.2 For maintenance purposes, a connection, or other means, shall be provided for crankcase inerting, and ventilating and gas concentration measurement.

15.9 Gas ignition in the cylinder

15.9.1 The requirements are as described in:

- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, *July 2018, Incorporating Notice No.1 & 2, Pt A-1 10.3 Regulations for internal combustion engines of piston type*; or
- *Rules and Regulations for the Construction and Classification of Ships for the Carriage of Liquefied Gases in Bulk, July 2018, Incorporating Notice No.1, Ch 16, 16.7 Special requirements for gas-fired internal combustion engines, as applicable*.

15.10 Gas admission valves

15.10.1 Gas admission valves, which control gas supply to the cylinder(s) according to the cylinder's (cylinders') actual gas demand. They shall be suitably certified safe for use in zone 1. Where gas admission valves are not rated for zone 1 use, it shall be documented that they are suitable for safe use in the proposed application. Documentation and analysis is to be based on IEC 60079-10-1 or IEC 60092-502. Evidence of suitability is to be submitted for consideration.

15.11 DF engines

15.11.1 DF engines shall be arranged to use either fuel oil or gas fuel for the main fuel charge and with pilot fuel oil for ignition. They are to be arranged for immediate changeover from gas use to fuel oil use. In the case of changeover to either fuel supply, the engines are to be capable of continuous operation using the alternative fuel supply without interruption to the supply of power.

15.11.2 Changeover to from fuel oil to gas shall be only possible at a power level where it can be done reliably and safely as demonstrated through testing.

15.11.3 Changeover from gas to fuel oil shall always be possible at all power levels.

15.11.4 Changeover from and to gas operation shall be automatic but manual interruption shall always be possible.

15.11.5 In case of a gas shut-off, the engines shall be capable of continuous operation on fuel oil only.

15.11.6 Gas admittance to the combustion chamber shall not be possible without operation of the pilot oil injection. Pilot oil injection shall be monitored using fuel oil pressure and combustion parameters.

15.12 GF engines

15.12.1 In case of failure of the spark ignition, the engine is to be shut down unless the failure can be limited to one cylinder, in which case the gas supply to the affected cylinder is to be immediately shut-off, the reliability and safety of which is to be considered in the risk analysis and demonstrated through testing.

15.13 Pre-mixed engines

15.13.1 Inlet manifolds, turbochargers, charge air coolers, etc. are to be regarded as parts of the fuel gas supply system. Failures of these components are likely to result in a gas leakage and are to be considered in the risk analysis (*see Pt 5, Ch 2, 15.3 Risk analysis*).

15.13.2 Flame arresters are to be installed before each cylinder head, unless otherwise justified in the risk analysis, considering the design parameters of the engine including, but not limited to, the gas concentration in the charge air system and the path length of the gas-air mixture in the charge air system.

15.14 Control, monitoring, alarm and safety systems

15.14.1 The engine control system is to be independent and separate from the safety system.

15.14.2 The gas supply valves are to be controlled by the engine control system or by the engine gas demand.

15.14.3 Combustion is to be monitored on an individual cylinder basis. Where poor combustion is detected on an individual cylinder, gas operation is to be allowed in accordance with the conditions specified in:

- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, *July 2018, Incorporating Notice No.1 & 2, Pt A-1 10.3 Regulations for internal combustion engines of piston type 10.3.1.6*.

Where monitoring of combustion for each individual cylinder is not practicable due to engine size and design, common combustion monitoring will be subject to consideration by LR.

15.14.4 Unless the risk analysis required in *Pt 5, Ch 2, 15.3 Risk analysis* proves otherwise, the monitoring and safety system functions for DF or GF engines are to be provided in accordance with *Table 2.15.2 Monitoring and safety system functions for DF and GF engines* in addition to the general monitoring and safety system functions given in:

- *Rules and Regulations for the Classification of Ships using Gases or other Low-flashpoint Fuels*, *July 2018, Incorporating Notice No.1 & 2, Pt A-1, 15.11 Regulations on safety functions of fuel supply systems*.

For DF engines, *Table 2.15.2 Monitoring and safety system functions for DF and GF engines* shall only be applied to gas mode.

Table 2.15.2 Monitoring and safety system functions for DF and GF engines

Parameter	Alarm	Automatic activation of the double block and bleed valves	Automatic switching over to fuel oil mode (*see* Note 1)	Engine shutdown
Abnormal pressures in the gas fuel supply line	X	X	X	X (*see* Note 5)
Gas fuel supply systems – malfunction	X	X	X	X (*see* Note 5)
Pilot fuel injection or spark ignition systems – malfunction	X	X (*see* Note 2)	X	X (*see* Notes 2 and 5)
Exhaust gas temperature after each cylinder – high	X	X (*see* Note 2)	X	X (*see* Notes 2 and 5)
Exhaust gas temperature after each cylinder, deviation from average – low (*see* Note 3)	X	X (*see* Note 2)	X	X (*see* Notes 2 and 5)
Cylinder pressure or ignition – failure, including misfiring, knocking and unstable combustion	X	X (*see* Notes 2 and 4)	X (*see* Note 4)	X (*see* Notes 2, 4 and 5)
Oil mist concentration in crankcase or bearing temperature – high (*see* Note 6)	X	X		X
Pressure in the crankcase – high (*see* Note 4)	X	X	X	
Engine stops – any cause	X	X		
Failure of the control-actuating medium and bleed valves	X	X	X	

Note 1. DF engine only, when running in gas mode.

Note 2. For GF engines, the double block-and-bleed valves and the engine shutdown may not be activated in case of specific failures affecting only one cylinder, provided that the concerned cylinder shall be individually shut off, and the safe operation of the engine in such conditions is demonstrated by the risk analysis.

Note 3. Required only if necessary for the detection of misfiring.

Note 4. In the case where the failure can be corrected by an automatic mitigation, only the alarm may be activated. If the failure persists after a given time, the safety actions are to be activated. The time period to activate safety actions shall be demonstrated to LR.

Note 5. GF engine only.

Note 6. Where required by *Pt 5, Ch 2, 10.8 Oil mist detection*.

Part 5, Chapter 14
Machinery Piping Systems

■ *Section 4*
Fuel oil pumps, pipes, fittings, tanks, etc.

4.17 Separate fuel oil tanks

4.17.7 Separate fuel oil tanks may be permitted on the open deck in the cargo area of oil and chemical tankers, carrying liquid cargoes having a flashpoint not exceeding 60°C and/or toxic liquid cargoes for which toxic vapour detection is specified in column “k” of the table of Chapter 17 of the IBC Code, subject to spill and fire safety considerations. Air and sounding pipes of separate fuel oil tanks are to comply with the requirements of *Pt 5, Ch 15, 2.5 Air and sounding pipes*.

Part 5, Chapter 21
Requirements for Condition Monitoring ~~Systems~~ and ~~Machinery~~ Condition-Based Maintenance Systems

■ *Section 1*
Requirements for Condition Monitoring ~~Systems~~ and ~~Machinery~~ Condition-Based Maintenance Systems

1.1 Scope

1.1.1 The requirements of this Chapter are applicable to condition monitoring ~~systems~~ and ~~machinery~~ condition-based maintenance systems which:

(a) provide control, alarm or safety functions for essential machinery and equipment (*see Pt 6, Ch 1, 2.1 General 2.1.1*) in accordance with manufacturers recommendations; or

(b) provide machinery condition related information as part of a machinery planned maintenance scheme for use as an alternative to machinery and equipment surveys required by the Regulations (*see Pt 1, Ch 3 Periodical Survey Regulations)* in accordance with LR's ShipRight procedures.

1.1.3 The requirements of this Section and LR's *ShipRight Procedures for Machinery Planned Maintenance and Condition Monitoring* are to be applied to condition monitoring systems where the assignment of the **ShipRight(MPMS(CM))** **~~MCM~~** descriptive note is requested.

1.1.4 The requirements of this Section and LR's *ShipRight Procedures for Machinery Planned Maintenance and Condition Monitoring* are to be applied to machinery condition-based maintenance systems that make use of predictive techniques where the assignment of the **~~MCBM~~** **ShipRight(MPMS(PT))** d~~D~~escriptive n~~N~~ote is requested in addition to the **~~MCM~~** **~~ShipRight(~~(MPMS(CM))** d~~D~~escriptive n~~N~~ote.

1.2 Plans and particulars

~~1.2.3 In addition to information required by *Pt 5, Ch 21, 1.2 Plans and particulars 1.2.1*, the documents listed in the *ShipRight Procedures for Machinery Planned Maintenance and Condition Monitoring* are to be submitted to LR for consideration where the **MCBM** Descriptive Note is requested.~~

Existing paragraphs 1.2.4 and 1.2.5 have been renumbered 1.2.3 and 1.2.4.

1.3 General requirements for condition monitoring systems

1.3.1 Condition monitoring equipment is to be capable of providing the service for which it is intended and is to satisfy the relevant requirements for condition monitoring equipment in LR's Type Approval System~~, *Product Assessment and Test Specification (TACM)*~~.

1.3.9 The condition monitoring equipment is to be installed in accordance with the manufacturer's instructions~~, *see* the *Product Assessment and Test Specification (PACM)*, or by an approved technical organisation as defined in the LR *ShipRight Procedures for Machinery Planned Maintenance and Condition Monitoring*~~, and to the satisfaction of the LR Surveyor.

1.3.10 Boilers and pressure vessels are not eligible for reduced survey intervention based on condition monitoring.

1.5 Requirements for systems providing machinery condition related information as part of ~~machinery~~ condition-based maintenance systems

1.5.1 In addition to the requirements of *Pt 5, Ch 21, 1.3 General requirements for condition monitoring systems*, condition monitoring equipment which provides ~~machinery~~ condition related information as part of a machinery planned maintenance scheme for use as an alternative to machinery and equipment surveys required by the Regulations is also to satisfy the relevant requirements of LR's *ShipRight Procedures for Machinery Planned Maintenance and Condition Monitoring*.

1.5.2 Where condition monitoring data is used as part of a ~~machinery~~ condition-based maintenance system, persons interpreting data and making diagnostic decisions are to be suitably competent, in accordance with ISO 18436 or an equivalent recognised National Standard. Evidence of competence, including training certificates of those providing analysis and data interpretation, are to be submitted and held on board. These certificates are to be made available to LR on request for audit and survey purposes.

~~1.5.4 The condition monitoring equipment is to be installed in accordance with the manufacturer's instructions, *see* the *Product Assessment and Test Specification (TACM)* or by an approved technical organisation as defined in the *ShipRight Procedures for Machinery Planned Maintenance and Condition Monitoring*, and to the satisfaction of the LR Surveyor.~~

1.5.4 Limiting parameters (alarms and warnings) are to be based on the manufacturer's guidelines, or a recognised International Standard.

Existing sub-Section 1.6 has been deleted and replaced with below.

1.6 Requirements for maintenance systems using predictive techniques

1.6.1 Machinery maintenance systems which make use of predictive techniques, when being used as an alternative to machinery and equipment surveys required by the Regulations, are also to satisfy the requirements of this Section and the relevant requirements of LR's *ShipRight Procedures for Machinery Planned Maintenance and Condition Monitoring.*

Part 6, Chapter 2
Electrical Engineering

■ *Section 9*
Rotating machines

9.1 General requirements

9.1.15 For high voltage machines, the stator insulation system is to be of a type that has undergone ~~type~~ design qualification testing in accordance with the applicable requirements of the following International Standards, or relevant alternatives acceptable to LR, to demonstrate its suitability for the operating voltage:

a) IEC 60034-18-31, *Rotating electrical machines – Part 18-31: Functional evaluation of insulation systems – Test procedures for form-wound windings – Thermal evaluation and classification of insulation systems used in rotating machines*;

b) IEC 60034-18-32, *Rotating electrical machines – Part 18-32: Functional evaluation of insulation systems – Test procedures for form-wound windings – Evaluation by electrical endurance*;

~~c) IEC TS 60034-18-33 *Rotating electrical machines – Part 18-33: Functional evaluation of insulation systems – Test procedures for form-wound windings – Multifactor evaluation by endurance under simultaneous thermal and electrical stresses*;~~

~~d)~~c) IEC 60034-18-34, *Rotating electrical machines – Part 18-34: Functional evaluation of insulation systems – Test procedures for form-wound windings – Evaluation of thermomechanical endurance of insulation systems*`;

~~e)~~d) IEC 60034-27-3, *Dielectric dissipation factor measurement on stator winding insulation of rotating electrical machines*.

Test samples are to be representative in terms of the number and size of conductors, coil construction~~,~~ and the combination of materials and manufacturing process.

9.1.21 The completed stator of high voltage rotating machines to be used for essential services is to be tested for partial discharge in accordance *with IEC 60034-27-1, Rotating electrical machines Part 27-1: Off-line partial discharge measurements on the winding insulation* or an alternative standard acceptable to LR. Copies of the test reports are to be provided to the Surveyor on request.

9.1.22 For high voltage rotating machines to be used for essential services, suitable access is to be provided which will enable visual inspections of the stator and field windings for signs of damage. Boroscopic and/or endoscopic inspection techniques may be used where appropriate. Areas to be capable of inspection are to include, but are not limited to:

- drive and non-drive ends of the machine;
- stator/core: core laminations, stator wedges, stator bars, space blocks, end windings and connection rings; flux shield and instrumentation;
- field/frame: field wedges, retaining ring and coil end turns.

9.1.23 Where the requirements of *Pt 6, Ch 2, General requirements paragraph 9.1.22* cannot be achieved, a means of connecting partial discharge monitoring equipment is to be installed. The means of connection is to enable Off-line periodic testing in accordance with the recommendations of the rotating machine manufacturer and *IEC 60034-27-1, Rotating electrical machines Part 27-1: Off-line partial discharge measurements on the winding insulation* or an alternative standard acceptable to LR. Alternatively, the requirements of *Pt 6, Ch 2, General requirements paragraph 9.1.24 may be applied.*

9.1.24 Where it is intended to install on-line partial discharge monitoring equipment, the high voltage rotating machine installation is to be provided with a means of connection which will enable the safe connection of the equipment once the rotating machine is in service. The means of connection is to enable on-line through-life testing in accordance with the recommendations of the rotating machine manufacturer and one of the following standards:

a) on-line testing:
   - PD IEC/TS 60034-27-2, *Rotating electrical machines Part 27-2: On-line partial discharge measurements on the stator winding insulation of rotating electrical machines*;
   - DD IEC/TS 61934, *Electrical insulating materials and systems – Electrical measurement of partial discharges (PD) under short rise time and repetitive voltage impulses*; or

b) an alternative International or National Standard acceptable to LR.

Existing paragraph 9.1.21 has been renumbered 9.1.25.

■ *Section 21*
Testing and trials

21.4 ~~Partial~~ On-line partial discharge testing of high voltage rotating machines for essential services

~~21.4.1 To enable future trend analysis, on completion of harbour acceptance trials or during sea acceptance trials, partial discharge measurements are to be conducted which will baseline the partial discharge characteristics of the rotating machine. A copy of the test report is to be retained on board and made available to the Surveyor on request.~~

~~21.4.2 At the first Annual Survey, or within 3 months of the due date, the partial discharge measurements required *by Pt 6, Ch 2, 21.4 Partial discharge testing of high voltage rotating machines for essential services 21.4.1* are to be repeated. A copy of the test report is to be retained on board and made available to the Surveyor on request.~~

~~21.4.3 At Complete Survey, or within 3 months of the due date, the partial discharge measurements required by *Pt 6, Ch 2, 21.4 Partial discharge testing of high voltage rotating machines for essential services 21.4.1* are to be repeated. A copy of the test report is to be retained on board and made available to the Surveyor on request.~~

~~21.4.4 The partial discharge measurement method to be used is to be acceptable to the rotating machine manufacturer. Particular attention is to be given to ensuring that:~~

~~a) the test voltage and frequency (i.e. ac, dc or ultra-low frequency and voltage level), and method selected are to be compatible with the insulation systems; and~~

~~b) the tests do not over stress or cause accelerated aging of the insulation system.~~

~~21.4.5 The measurements required by *Pt 6, Ch 2, 21.4 Partial discharge testing of high voltage rotating machines for essential services 21.4.1* to *Pt 6, Ch 2, 21.4 Partial discharge testing of high voltage rotating machines for essential services 21.4.3* are to be conducted and recorded in accordance with one of the following standards as appropriate to the design and application of the rotating machine:~~

~~a) Off-line testing:~~

- ~~IEC TS 60034-27, *Rotating electrical machines – Part 27: Off-line partial discharge measurements on the stator winding insulation of rotating electrical machine*;~~

~~b) On-line testing:~~

- ~~PD IEC/TS 60034-27-2:2012, *Rotating electrical machines Part 27-2: On-line partial discharge measurements on the stator winding insulation of rotating electrical machines*;~~
- ~~DD IEC/TS 61934:2011, *Electrical insulating materials and systems — Electrical measurement of partial discharges (PD) under short rise time and repetitive voltage impulses*; or~~
- ~~an alternative International or National Standard acceptable to LR.~~

~~21.4.6 The test reports required by *Pt 6, Ch 2, 21.4 Partial discharge testing of high voltage rotating machines for essential services 21.4.1* to *Pt 6, Ch 2, 21.4 Partial discharge testing of high voltage rotating machines for essential services 21.4.3* are to record the method and equipment used in sufficient detail to ensure the tests can be repeated consistently throughout the service life of the rotating machine.~~

~~21.4.7 The test reports required by *Pt 6, Ch 2, 21.4 Partial discharge testing of high voltage rotating machines for essential services 21.4.1* to *Pt 6, Ch 2, 21.4 Partial discharge testing of high voltage rotating machines for essential services 21.4.1* are to include, but are not limited to, the details recommended by the test standard to be applied. *See Pt 6, Ch 2, 21.4 Partial discharge testing of high voltage rotating machines for essential services 21.4.5*.~~

~~21.4.8 The documentation required by *Pt 6, Ch 2, 21.4 Partial discharge testing of high voltage rotating machines for essential services 21.4.6* is to be provided to the end user as part of the as-built documentation for the rotating machine.~~

~~21.4.9 Partial discharge measurements are to be evaluated by suitably qualified and experienced personnel, and are to remain within the manufacturer's recommendations.~~

~~21.4.10 Where partial discharge measurements exceed the manufacturer's recommendations, corrective action is to be taken.~~

~~21.4.11 Where on-line partial discharge monitoring equipment is installed, which is capable of being used to alert the ship's staff of an increase in partial discharge activity, then the output is to be included as an alert, with alert levels set, and the actions required to be specified by the manufacturer of the rotating machine.~~

21.4.1 Where on-line partial discharge monitoring equipment is installed for the monitoring of high voltage rotating machines used to provide essential services, the method used is to be appropriate for the design and application of the rotating machine, and conducted and recorded in accordance with:

(a) PD IEC/TS 60034-27-2:2012, *Rotating electrical machines Part 27-2: On-line partial discharge measurements on the stator winding insulation of rotating electrical machines*;

(b) DD IEC/TS 61934:2011, *Electrical insulating materials and systems – Electrical measurement of partial discharges (PD) under short rise time and repetitive voltage impulses*; or

(c) an alternative International or National Standard acceptable to LR.

21.4.2 The partial discharge measurement method used is to be acceptable to the rotating machine manufacturer. Particular attention is to be given to ensuring that:

- the test voltage and frequency (i.e. a.c., or ultra-low frequency and voltage level), and method selected are to be compatible with the insulation systems; and
- the tests do not over stress or cause accelerated ageing of the insulation system.

21.4.3 The test reports required by *Pt 6, Ch 2, 21.4 On-line partial discharge testing of high voltage rotating machines for essential services 21.4.1* are to:

- record the method and equipment used in sufficient detail to ensure that the tests can be repeated consistently throughout the service life of the rotating machine; and
- include, but are not limited to, the details recommended by the test standard to be applied.

21.4.4 Where partial discharge monitoring equipment has been installed in accordance with *Pt 6, Ch 2, 21.4 On-line partial discharge testing of high voltage rotating machines for essential services 21.4.1*, to enable through-life trend analysis:

(a) measurements are to be recorded at harbour acceptance trials or sea trials to baseline the partial discharge characteristics of the rotating machine, and then repeated annually; and

(b) a copy of the test reports and data is to be retained on board and made available to the Surveyor on request.

Part 7, Chapter 12
Passenger and Crew Accommodation Comfort

■ *Section 1*
General requirements

1.2 Definitions

1.2.3 **Noise level** is defined as the A-weighted energy equivalent sound pressure level measured in accordance with ISO 2923.

1.2.4 **Vibration level** is defined by the application of ~~ISO 6954:2000~~ ISO 20283-5.

The vibration level is defined as the overall frequency weighted r.m.s. value of vibration during a period of steady-state operation over the frequency range 1 to 80 Hz.

■ *Section 2*
Noise

2.2 Passenger accommodation and public spaces

2.2.2 For cabins bordering discotheques and similar entertainment ~~areas~~ spaces, the deck and bulkhead sound insulation is to be sufficient to ensure that the maximum cabin noise levels are not exceeded even when high external noise levels prevail. Noise from entertainment spaces shall be considered as transient noise and should meet the requirements stated in *Pt 7, Ch 12, 2.6 Transient noise*.

2.2.3 Acceptance of noise levels greater than those specified in *Table 12.2.1 Passenger ships - Maximum noise levels in dB(A)* may be considered where agreed between the Owner and Builder at specification/contract stage. Not more than 20 per cent of the passenger cabins, 30 per cent of the public spaces and 20 per cent of the crew cabins should exceed the relevant noise criteria by more than 3 dB(A).

2.2.4 Acoustic insulation of bulkheads and decks between passenger spaces is to be generally in accordance with the values of the weighted apparent sound reduction index ~~R_w~~ R'_w as given in *Table 12.2.2 ~~Minimum air-borne sound insulation~~ Minimum apparent airborne sound insulation indices,* ~~R_w~~, R'_w, calculated using ISO 717/1. *See also Pt 7, Ch 12, 2.2 Passenger accommodation and public spaces 2.2.6*.

(Part only shown)

Table 12.2.2 ~~Minimum air-borne sound insulation indices, R_w~~ Minimum apparent airborne sound insulation indices, R'_w

Location		Acceptance Numeral		
		1	2	3
Passenger cabins:	Standard	~~40~~ 41	~~38~~ 39	~~37~~ 38
	Superior			
Cabin to corridor:	Standard			~~34~~ 35
	Superior			

(Part only shown)

2.2.5 For the purpose of selecting acoustic sound insulation, the following sound noise levels may be used. ~~with the agreement of the Owner and Builder:~~ The frequency spectrum used should be as defined in ISO 717-1: spectrum No. 2 for discotheques and spectrum No. 1 for others. Evaluation should include the frequency range down to 50 Hz 1/3-octave band:

2.2.6 Acceptance of bulkhead and deck acoustic insulation values less than those specified in ~~*Table 12.2.2 Minimum air-borne sound insulation indices, R_w*~~ *Table 12.2.2 Minimum apparent airborne sound insulation indices, R'_w* may be considered where agreed between the Owner and Builder. Not more than 20 per cent of the interfaces tested should have airborne sound insulation indices, ~~R_w~~ R'_w, more than 3 dB(A) lower than the minimum specified values.

2.3 Crew accommodation and work areas

(Part only shown)

Table 12.2.4 Crew work areas – maximum noise levels in dB(A)

Location	dB(A) level
~~Machinery space(continuously manned) e.g. stores~~	~~90~~
….	
Wheelhouse, chartrooms, radar rooms	65
…	

2.5 Impact insulation

2.5.2 For passenger and crew cabins located below or adjacent to dance floors, stages, aerobics and gymnasium areas, jogging tracks or other areas where impact noise is generated, the ~~normalised impact sound pressure level~~ normalised field measured impact sound pressure level ~~measured~~ within the cabins is not to exceed 45 dB.

2.5.3 For public rooms under dance floors, stages, aerobics and gymnasium areas, jogging tracks or other areas where impact noise is generated, the ~~normalised impact sound pressure level~~ normalised field measured impact sound pressure level within the space is not to exceed 55 dB.

2.5.4 For passenger cabins, ~~normalised impact sound pressure level~~ normalised field measured impact sound pressure level, ~~$L_{n,w}$~~ $L'_{n,w}$, calculated using ISO 717/2, is to be generally in accordance with the values stated in ~~*Table 12.2.5 Passenger cabins normalised impact maximum sound pressure level L n,w*~~ *Table 12.2.5 Passenger cabins normalised field measured impact sound pressure level* $L'_{n,w}$. *See also Pt 7, Ch 12, 2.5 Impact insulation 2.5.5.*

Table 12.2.5 ~~Passenger cabins normalised impact maximum sound pressure level $L_{n,w}$~~ Passenger cabins normalised field measured impact sound pressure level $L'_{n,w}$

2.5.5 Acceptance of normalised impact sound pressure levels greater than those specified in ~~*Table 12.2.5 Passenger cabins normalised impact maximum sound pressure level L n,w*~~ *Table 12.2.5 Passenger cabins normalised field measured impact sound pressure level* $L'_{n,w}$ may be considered for assignment of the applicable class notation where agreed between the Owner, Builder and LR. No more than 20 per cent of the passenger cabins tested should exceed the levels specified by more than 3 dB.

2.6 Transient noise

(Part only shown)

2.6.2 The maximum sound pressure level (~~L_{max}~~ $L_{pAS,max}$) emanating from any machinery or system caused by a single event that produces a noise 'spike' compared to the reference condition sound level (such as vacuum systems or valve operations) is not to cause an increase in noise in comparison with the reference condition (background noise) as below:

A tolerance of ~~+1 dB(A)~~ +3 dB(A) may be applied to 5 per cent of cabins and public areas in each fire zone on each deck. This criterion is generally applicable to the specified maximum noise levels for the space concerned.

■ *Section 3*
Vibration

3.1 Assessment criteria

3.1.2 The limits apply to vertical, ~~fore and aft and athwartship~~ longitudinal and transverse vibrations which are to be assessed separately.

(Part only shown)

Table 12.3.1 Passenger ship - Maximum vibration levels

Standard:	~~ISO 6954:2000~~ ISO 20283-5
Units:	~~Peak velocity (1–80 Hz) velocity mm/s rms~~ Frequency weighted velocity level (1–80 Hz), mm/s r.m.s.

(Part only shown)

Table 12.3.2 Crew spaces – Maximum vibration levels

Standard:	~~ISO 6954:2000~~ ISO 20283-5
Units:	~~Frequency weighted (1–80 Hz) velocity mm/s rms~~ Frequency weighted velocity level (1–80 Hz), mm/s r.m.s.

■ *Section 4*
Testing

4.2 Test conditions

4.2.1 Test conditions for the surveys are to be in accordance with those detailed in ISO 2923 and ~~ISO 6954:2000~~ ISO 20283-5 as applicable.

(Part only shown)
4.2.4 The test conditions required for the vibration and noise measurements are to be in accordance with the following conditions:
(a) For passenger ships, prior to measurement surveys being carried out, the ship operating condition where the worst conditions are experienced between 0 and 85 per cent maximum continuous rating of the propulsion machinery is to be determined. To establish this condition, four measurement positions are to be defined with the agreement of LR and measurements taken of the parameters of interest at ship speeds corresponding to percentages of the maximum continuous rating of the propulsion machinery increasing up to 40 per cent MCR in 10 per cent intervals and from 40 per cent in 5 per cent intervals up to the 85 per cent maximum continuous rating of the propulsion machinery. If the 85 per cent maximum continuous rating condition is found to be the worst condition, then this will form the trial operating condition. However, if a lower speed condition is found to be worse than the 85 per cent maximum continuous rating condition then both that condition and the 85 per cent maximum continuous rating condition will form the trial operating conditions. Where unavoidable any barred range within the values required for the trial operating condition may be excluded on agreement between Owner and Builder subject to approval by LR. Other operating conditions for testing can be agreed between Owner and Builder.
(i) ~~For passenger ships, intermittently~~ Intermittently run equipment such as transverse propulsion units are to be operated at ~~60 per cent and for all other ships~~ 40 per cent of their rated power for additional measurements in surrounding ship areas. If such equipment is intended for long-term operation, e.g. stabilisers, or long-term intermittent dynamic positioning (DP) mode, measurements shall be made for ensuring compliance with the general noise and vibration limits. If such systems are intended for short term intermittent operation only, for instance during port manoeuvres, the noise and vibration levels should be measured for information only. Definition of long-term DP mode can be agreed between Owner and Builder.

4.3 Noise measurements

4.3.3 When outfitting is complete, and all soft furnishings are in place, sound insulation indices for passenger spaces are to be determined in accordance with ~~ISO 140~~ ISO 16283-1. Cabin to cabin indices are to be determined from a minimum of three locations for each cabin type within the passenger accommodation, the number of test locations being agreed with LR. If the partition surface area is less than 10 m², an area of 10 m² shall be used for the calculation of the R'_w index, unless otherwise agreed.

4.3.4 If required, impact sound measurements are to be carried out in accordance with ~~ISO 140/7~~ ISO 16283-2 and presented in accordance with ISO 717/2. *See Pt 7, Ch 12, 4.4 Noise measurement locations 4.4.4*.

4.4 Noise measurement locations

4.4.1 Measurement locations are to be chosen so that the assessment represents the overall noise environment on board the ship. In addition to the requirements of *IMO Resolution MSC.337(91) – Adoption of the Code on Noise Levels on Board Ships – (Adopted on 30 November 2012)The Annex below is consolidated into Resolution MSC.337(91)* for crew spaces, all public spaces shall be surveyed. ~~and at least 50 per cent of passenger cabins in the after third of the ship, and 25 per cent elsewhere, are to be surveyed.~~ For passenger cabins the following minimum number of cabins shall be measured:
$n < 10$: all cabins,
$n < 50$: 50 per cent of cabins,
$n < 500$: 25 per cent of cabins,
$n > 500$: 15 per cent of cabins
where n is the total number of passenger cabins.
At least 40 per cent of the crew cabins shall be measured. For ships with a large number of crew cabins, e.g. cruise ships, a minimum of 15 per cent of the crew cabins should be measured. 50 per cent of the measurements in crew and passenger areas shall be located in the after third of the ship. Distribution of the measurement locations is to be agreed by LR.

4.4.4 The number of and locations for impact noise measurements are to be agreed between the Builder, Owner and LR. The measurements are to be carried out when the ship is in ~~harbour~~ a condition with steady and low background noise. The number and location of measurements are to take account of all different combinations of construction, areas of application, types of cabin and spaces below.

4.5 Vibration measurements

4.5.1 Vibration measurements are to be conducted in accordance with ~~ISO 6954:2000~~ ISO 20283-5.

4.6 Vibration measurement locations

4.6.4 At all locations, vibrations in the vertical direction are to be assessed. Sufficient measurements in the ~~athwartships and fore and aft~~ longitudinal and transverse directions are to be taken to define global deck vibrations in at least two locations on each deck.

■ *Section 5*
Noise and vibration survey reporting

5.1 General

5.1.4 The survey report is to be submitted to LR~~'s Southampton GTC Office (MSC/TID)~~ for evaluation and confirmation that the results are in accordance with the noise and vibration levels specified in these Rules and/or agreed between the Owner and Builder. The assignment of a Class Notation or the issue of a Statement of Compliance will be subject to confirmation by ~~a~~ an LR ~~MSC/TID~~ specialist with a competency level of 2 or higher within Passenger and Crew Accommodation Comfort (PCAC) (ADV198).

5.2 Noise

(Part only shown)

5.2.1 The reporting of results is to comply with ISO 2923 and *IMO Resolution MSC.337(91) – Adoption of the Code on Noise Levels on Board Ships – (Adopted on 30 November 2012)The Annex below is consolidated into Resolution MSC.337(91)* and is to include:

(d) Trial details:

- Sea state.
- Draught.

5.3 Vibration

(Part only shown)

5.3.1 The report is to contain the following information:

(b) Where ISO ~~6964:2000~~ 20283-5 is used, the frequency-weighted overall r.m.s. vibration levels tabulated for all measurement locations calculated using the weighting functions and methodology stated in the standard.

(d) Trial details:

- Sea state.
- Draught.

■ *Section 7*
Referenced Standards

7.1 Noise

7.1.1 The following National and International Standards for noise are referred to in these Rules:

- ~~ISO 2923~~ ISO 2923:1996/Cor 1:1997, *Acoustics – Measurement of noise on board vessels*.
- ~~ISO 717/1~~ ISO 717-1:2013, *Acoustics – Rating of sound insulation in buildings and of building elements; Part 1: Airborne sound insulation*.
- ~~ISO 717/2~~ ISO 717-2:2013, *Acoustics – Rating of sound insulation in buildings and of building elements; Part 2: Impact sound insulation*.
- IMO Resolution MSC.337(91) – *Adoption of the Code on Noise Levels on Board Ships – (Adopted on 30 November 2012)The Annex below is consolidated into Resolution MSC.337(91).*
- ~~IEC Publication 651, *Sound level meters*~~ IEC 61672, *Sound level meters* (all parts), or earlier versions.
- ~~ISO 140/4, *Acoustics – Measurement of sound insulation in buildings and of building elements; Part 4: Field measurements of airborne sound insulation between rooms*~~. ISO 16283-1:2014/Amd 1:2017, *Acoustics – Field measurement of sound insulation in buildings and of building elements – Part 1: Airborne sound insulation*.
- ~~ISO 140/7, *Acoustics – Measurement of sound insulation in buildings and of building elements; Part 7: Field measurements of impact sound insulation of floors*~~. ISO 16283-2:2018, *Acoustics – Field measurement of sound insulation in buildings and of building elements – Part 2: Impact sound insulation*.

7.2 Vibration

7.2.1 The following National and International Standards for vibration are referred to in these Rules:

- ~~ISO 6954:2000, *Mechanical vibration and shock – Guidelines for the measurement, reporting and evaluation of vibration with regard to habitability on passenger and merchant ships.*~~ ISO 20283-5:2016, *Mechanical vibration – Measurement of vibration on ships – Part 5: Guidelines for measurement, evaluation and reporting of vibration with regard to habitability on passenger and merchant ships.*
- ~~ISO 80041, *Human response to vibration. Measuring instrumentation*~~. ISO 8041-1:2017, *Human response to vibration – Measuring instrumentation – Part 1: General purpose vibration meters* (or earlier versions).

Part 8, Chapter 1
Application

■ *Section 1*
Scope

1.1 General

(Part only shown)

Table 1.1.1 Ice and cold operations

Cold operations					
~~Provisional~~ Rules for the Winterisation of Ships	Section 1		Application		
	Section 2	Hull materials	Low temperature operations	Hull construction materials	**Winterisation H(*t*)**
	Section 3	Equipment and systems	Low temperature operations	Mild extent of winterisation	**Winterisation C(*t*)**
				Moderate extent of winterisation	**Winterisation B(T*t*)**
				Extensive extent of winterisation	**Winterisation A(*t*)**
	Section 3 Section 4	Equipment		Materials of exposed equipment	**Winterisation M Winterisation Mn**
	Section 9	Systems		Winterisation system redundancy	**Winterisation WR**

■ *Section 2*
Ice environment

2.2 Definitions

Table 1.2.2 Comparison of ice Standards

Lloyd's Register class notation	**Finnish-Swedish Ice Class**	**Canadian type**
Ice Class 1AS FS(+) **Ice Class 1AS FS**	IA Super	A
Ice Class 1A FS(+) **Ice Class 1A FS**	IA	B
Ice Class 1B FS(+) **Ice Class 1B FS**	IB	C
Ice Class 1C FS(+) **Ice Class 1C FS**	IC	D
Ice Class 1D	—	~~D~~E
Ice Class 1E	—	E

2.3 Application

2.3.3 Operation in the region between 7/10 and 1/10 in the ice-covered regions is possible with due care for ships with no ice class. For ships operating for extended periods in these areas, it will be necessary to specify and design for a minimum temperature for the hull materials. To cover all situations for a non-ice class ship, the material requirements of ~~*The Provisional Rules for the Winterisation of Ships*~~ the *Rules for the Winterisation of Ships, July 2019,* are recommended.

2.5 National Authority requirements

2.5.3 Ships intending to navigate in the Canadian Arctic must comply with the *Canadian Arctic Shipping Safety Pollution Prevention Regulations* under the *Arctic Waters Pollution Prevention Act* and the *Canada Shipping Act, 2001* ~~established by the Consolidated Regulations of Canada, 1978, Chapter 353, in respect of which Lloyd's Register is authorised to issue Arctic Pollution Prevention Certificates~~.

2.5.4 The Canadian Arctic areas have been divided into shipping safety control zones relative to the severity of the ice conditions experienced and, in addition to geographic boundaries, each zone has seasonal limits affecting the necessary Ice Class notation required to permit operations at a particular time of year. It is the responsibility of the Owner to determine which notation is most suitable for their requirements.

~~2.5.5 The Canadian Authorities recognise that in the period November 6 to July 31 and any extension to that period declared by the Canadian Coast Guard, oil and bulk chemical tankers which qualify for Canadian Type A, B, C and D as indicated in *Table 1.2.2 Comparison of ice Standards* are suitable for operating in designated ice control zones within Canadian waters, off the east coast of Canada south of 60° north latitude. For all Type E tankers operating in this zone during the specified period, the Canadian Authorities will require either additional hull strength in way of the forward wing cargo tanks port and starboard, or the level of oil or chemical in these tanks to be not higher than one metre below the waterline of the ship in her condition of transit. Where the latter arrangement is adopted, the effect on longitudinal strength is to be considered.~~

2.5.5 Except as otherwise provided by the *Canadian Arctic Shipping Safety Pollution Prevention Regulations*, Canadian vessels in polar waters and foreign vessels in a shipping safety control zone must conform to the requirements of *Chapter XIV – Safety Measures for Ships Operating in Polar Waters* of SOLAS.

■ *Section 3*
Air environment

3.1 Air temperature

3.1.1 For ships intended to operate in cold regions, the temperature on exposed surfaces is to be considered. *See* the ~~*Provisional*~~ *Rules for the Winterisation of Ships, July 2019*.

■ *Section 4*
Icing environment

4.1 Ice accretion

4.1.1 For ships intended to operate in cold regions, the build up of ice on exposed surfaces is to be considered. *See* the ~~*Provisional*~~ *Rules for the Winterisation of Ships, July 2019*.

Part 8, Chapter 2
Ice Operations - Ice Class

■ *Section 2*
General hull requirements for navigation in ice – All ice classes

2.3 Rudder and steering arrangements

2.3.2 The design ice force on the rudder, based on the maximum rudder torque, shall be transmitted to the rudder stoppers without damage to the steering system.

2.3.3 The design ice force on the rudder stopper shall be considered as $F_s = M_x/d_s$, where M_x is the maximum design rudder torque determined according to the requirements of the *Finnish-Swedish Ice Class Rules* for ships assigned the notations **Ice Class 1AS FS**, **1A FS** and *Pt 8, Ch 2, 10.24 Rudders* for ships assigned Polar Class (**PC**) notations, and d_s is the distance between the centre of the rudder stock and the rudder stopper. The allowable stresses given in *Table 2.2.1 Allowable stress in rudder, stopper, ice knife and supporting structure in way of rudder stopper, ice knife* are not to be exceeded in the stoppers, their supporting structure and the throat of the stopper welds.

2.3.4 Rudder stoppers are to be arranged such that protection of the steering gear is provided two degrees before the maximum travel of the steering gear.

2.3.5 The steering gear, rudder stock and upper edge of the rudder are to be protected from loads from ice impact when operating astern. A robust ice knife or equivalent means of protecting the rudder head and upper edge of the rudder is to be fitted to ships assigned the notations **Ice Class 1AS FS**, **1A FS**, and to ships assigned Polar Class (**PC**) notations.

2.3.6 The width of the ice knife shall provide protection to the rudder two degrees either side of the centreline. The lower edge of the ice knife should extend below the upper edge of the rudder's trailing edge or lower ice waterline, whichever is the lowest. For a ship with large draught variations, the ice knife shall extend below the upper edge of the rudder's trailing edge.

2.3.7 The design force for the ice knife, F_k, shall be determined as $F_k = phl$, where p is the ice pressure and h is the ice load height calculated according to the stern hull area according to the requirements of the *Finnish-Swedish Ice Class Rules* for ships assigned the notations **Ice Class 1AS FS, 1A FS** or *Pt 8, Ch 2, 10.6 Design load patch* and *Pt 8, Ch 2, 10.7 Pressure within the design load patch* for ships assigned Polar Class (**PC**) notations, respectively. The load length, l, is to be considered according to the ice knife construction, but in general is to be taken as the support frame transverse spacing.

2.3.8 For the Ice Classes **1AS FS, 1A FS** and Polar Class **(PC) notations**, due regard is to be paid to the excessive load caused by the rudder being forced out of the midship position when backing into an ice ridge. When vessels are intended to operate with significant time in astern operation, then the hull strength is to be based on the method used in the forward region; however, due consideration may be given to the anticipated power in this mode of operation.

2.3.9 For plated structures, the thickness of the boundaries of the ice knife structure is not to be less than that of the rudder side plating.

Table 2.2.1 Allowable stress in rudder stopper, ice knife and supporting structure in way of rudder stopper, ice knife

	Von Mises stress, in N/mm^2	Shear stress, in N/mm^2
Allowable stress	235/k	138/k, *see* Note 1

Where

k = 235 / s_0

s_0 = specified minimum yield stress of the material, in N/mm^2

Note 1. When the direct calculation is based on beam theory, the allowable shear stress must be not be greater than 122/k.

■ *Section 10*
Hull strengthening requirements for navigation in multi-year ice conditions – Ice Classes PC1, PC2, PC3, PC4, PC5, PC6, PC7 and Icebreaker

10.1 Hull areas

10.1.7 If a ship is intended to operate astern in ice regions, the aft section of the ship is to be designed based on the bow and bow intermediate hull area requirements. *See* the ~~Provisional Rules for Stern First Ice Class Ships~~ *Rules for Stern First Ice Class Ships, November 2019*.

10.8 Hull area factors

10.8.3 Due to their increased manoeuvrability, ships having propulsion arrangements with azimuth thruster(s) or podded propellers are to have specially considered stern icebelt, S_{-i}, and stern lower, S_{-l}, hull area factors. *See* ~~*The*~~ the ~~*Provisional Rules for Stern First Ice Class Ships*~~ *Rules for Stern First Ice Class Ships, November 2019.*

10.24 Rudders

10.24.1 Rudder scantlings, posts, rudder horns, solepieces, rudder stocks, steering engines and pintles are to be dimensioned in accordance with *Pt 3, Ch 6 Aft End Structure* and *Pt 3, Ch 13 Ship Control Systems* as appropriate. The speed used in the calculations is to be the maximum service speed or that given in *Table 2.10.3 Minimum Speed*, whichever is the greater. When used in association with the speed given in *Table 2.10.3 Minimum Speed*, the rudder profile coefficients are to be taken as 1,1.

10.24.2 For the astern condition the actual astern speed or half the minimum speed defined in *Table 2.10.3 Minimum speed* is to be used, whichever is greater.

10.24.3 The section modulus of the solepiece calculated in accordance with *Pt 8, Ch 2, 10.24 Rudders 10.24.1* and *Pt 8, Ch 2, 10.24 Rudders 10.24.2* need not be greater than three times the section modulus of the solepiece, calculated in accordance with *Pt 3, Ch 13 Ship Control Systems* using the actual maximum service speed.

10.24.4 Local scantlings of rudders are to be determined considering that the rudder belongs to the stern ice belt/ice belt lower, depending on rudder location with respect to the lower extent of the ice belt. Rudder local plating and framing located above the lower extent of the main ice belt are to be dimensioned using the stern ice belt area factor applicable to the relevant Polar Class. Rudder

local plating and framing located below the lower extent of the main ice belt are to be dimensioned using the stern lower ice belt area factor applicable to the relevant Polar Class.

10.24.5 For scantlings of the rudder blade the plate thickness is to be determined in accordance with *Pt 8, Ch 2, 10.9 Shell plate requirements 10.9.1* using the rudder web frame spacing. The aspect ratio of the panel under consideration is to be used to determine the appropriate selection of formulae for transverse or longitudinally framed plating. Where the aspect ratio is 1,0, the panel is to be considered transversely framed.

10.24.6 The vertical and horizontal web thickness is not to be less than $0,7t_R$, but is not to be taken as less than 8 mm, where t_R is the rudder plate thickness.

10.24.7 The mainpiece is to be dimensioned in accordance with *Pt 3, Ch 13 Ship Control Systems*, utilising the basic stock diameter derived using in the minimum speed in *Table 2.10.3 Minimum speed*.

Table 2.10.3 Minimum speed

Ice Class	Minimum speed, in knots	Ice Class	Minimum speed, in knots
PC7	18	Icebreaker, PC7	22
PC6	20	Icebreaker, PC6	24
PC5	22	Icebreaker, PC5	28
PC4	25	Icebreaker, PC4	32
PC3	28	Icebreaker, PC3	35
PC2	31	Icebreaker, PC2	38
PC1	34	Icebreaker, PC1	42

Existing sub-Sections 10.24 to 10.27 have been renumbered 10.25 to 10.28.

■ *Section 11*
Machinery strengthening requirements for navigation in multi-year ice conditions – Ice Classes PC1, PC2, PC3, PC4, PC5, PC6, ~~and~~ PC7 and Icebreaker

11.6 Materials exposed to low air temperature

11.6.1 Materials of essential components exposed to low air temperature shall be of steel or other approved ductile material. An average impact energy value of 20 J taken from three Charpy V tests is to be obtained at 10°C below the lowest design temperature. *See also ~~the~~* the *~~Provisional~~ Rules for the Winterisation of Ships, July 2019~~*.

11.24 Steering arrangements

11.24.1 The steering gear for ships assigned the notation **Icebreaker** should be designed such that the rudder is centred automatically, immediately before the ship goes astern.

11.24.2 The effective holding torque of the rudder actuator, at safety valve set pressure, is obtained by multiplying the open water torque requirements (Q_R) at open water design speed (maximum 18 knots) determined from *Pt 3, Ch 13, 2 Rudders*, by the factor obtained from *Table 2.11.5 Steering gear holding torque factor*.

Table 2.11.5 Steering gear holding torque factor

Ice Class	PC1	PC2	PC3	PC4	PC5	PC6	PC7
Holding torque factor	5	5	3	3	3	2	1,5

11.24.3 The rudder actuator is to be protected by torque relief arrangements, assuming the turning speeds obtained from *Table 2.11.6 Rudder turning speed for relief valve discharge capacity* without undue pressure rise.

Table 2.11.6 Rudder turning speed for relief valve discharge capacity

Ice Class	PC1, PC2	PC3, PC4, PC5	PC6, PC7
Rudder turning speed (degrees/second)	8	6	4

11.24.4 For icebreakers, additional fast acting torque relief arrangements (acting at 15 per cent higher pressure than the set pressure of safety valves in *Pt 8, Ch 2 11.24 Steering arrangements 11.24.2*) are to provide effective protection of the rudder actuator in case the rudder is pushed rapidly hard over against the stops assuming the turning speeds obtained from *Table 2.11.7 Rudder turning speed for fast acting relief valve discharge capacity*. The arrangement is to be such that steering capacity is readily regained. Fast acting torque relief arrangements are recommended for ships without the **Icebreaker** notation.

Table 2.11.7 Rudder turning speed for fast acting relief valve discharge capacity

Ice Class	PC1, PC2	PC3, PC4, PC5	PC6, PC7
Rudder turning speed (degrees/second)	40	20	10

Existing sub-Section 11.24 has been renumbered 11.25.

■ *Section 12*
Requirements for Icebreaker(+)

12.5 General arrangement

12.5.7 For icebreakers installed with podded propulsion or azimuth thrusters, *see* the ~~*Provisional Rules for Stern First Ice Class Ships*~~ *Rules for Stern First Ice Class Ships, November 2019*.

12.10 Winterisation

(Part only shown)
12.10.1 Where a winterisation notation is assigned in compliance with the ~~Provisional Rules for the Winterisation of Ships~~ *Rules for the Winterisation of Ships, July 2019*, the following features are to be additionally considered;

12.8 Rudder and steering arrangements

12.8.1 Rudder posts, rudder horns, solepieces, rudder stocks and pintles are to be dimensioned in accordance with *Pt 8, Ch 2, 10.24 Rudders*. The minimum speed for rudder dimensioning purposes is to be taken as the speed required for the assigned Polar Class as a minimum. Increases above the minimum speed may be required based on the operational profile. ~~*Pt 3, Ch 6 Aft End Structure* and *Pt 3, Ch 13 Ship Control Systems* as appropriate. The speed used in the calculations is to be the maximum service speed or that given in *Table 2.12.2 Minimum speeds*, whichever is the greater.~~

12.8.2 Steering arrangements are to be in accordance with *Pt 8, Ch 2, 11.24 Steering arrangements*. The arrangements are to comply with the assigned Polar Class as a minimum. Increases above the minimum requirements may be required based on the operational profile.

Table 2.12.2 Minimum speeds

Ice thickness, m	Ship speed, kn
1	25
1,5	27
2	29
3	31

~~12.8.2 In the case of twin rudders operated by a single steering gear, provision is to be made for each rudder to be readily disconnected and secured.~~

~~12.8.3 Rudders should be located inboard, clear of the aft end, and as low as practicable to reduce the impact of ice.~~

Published by Lloyd's Register Group Limited
Registered office (Reg. no. 08126909)
71 Fenchurch Street, London, EC3M 4BS
United Kingdom